

Developing Hantavirus Mitigation Procedures for Cultural Resources

During the summer of 1996, an interdisciplinary team of National Park Service (NPS) employees developed Hantavirus mitigation procedures as an integral element of a preservation project to stabilize and partially restore a modest, three-room frame cabin at Agate Fossil Beds National Monument in northwestern Nebraska. The Harold J. Cook Homestead Cabin, or "Bone Cabin" as it is also known, is nationally significant for its association with early 20th century paleontological investigations of fossil deposits in the Niobrara River Valley. The mitigation efforts affected all aspects of the work, from the decontamination, removal and storage of architectural and artifact samples, to structural stabilization and exterior restoration. The preservation treatment represented a synthesis of traditional preservation and conservation procedures, historic accuracy, and health and safety concerns.

The preservation strategy for this project was to restore the exterior of the Bone Cabin to the primary historic period of 1909-1923. During this period, the cabin evolved from a one-room to a three-room homestead structure, then to a summer headquarters for excavation at the nearby buttes. Following limited seasonal use and two short periods of domestic use, the Bone Cabin was abandoned in 1951. Over time, its structurally minimal design, vandalism, and the impact of severe weather conditions contributed to its decline.

Because the emphasis on the work was the significance of the structure as an interpretive form on the landscape, the cabin was to be stabilized, the exterior to be restored, and the interior surface materials to be removed. With the exception of selected wall, ceiling and floor samples, interior finishes would not be retained. The samples were collected for their intellectual content, and interpretive and archival reference. This was of particular importance because a concurrent goal of the project was to identify and document the evolution of the cabin from the period of about 1904 through the 1950s, as part of information collection for a historic structure report. The building would not be occupied following completion of the project, nor would it be open to the public.

The Disease

The impetus for this activity was the 1995 confirmation of Hantavirus-positive mice in the general area of Agate Fossil Beds. The Hantavirus has gained national attention following the 1993 "outbreak" in the Four Corners Area; however, the disease itself has been present for centuries, in numerous strains. On the North American Continent, the disease is associated with Hantavirus Pulmonary Syndrome (HPS). It is carried by rodent hosts. Of the nine Hantaviruses indigenous to North American rodents, the most common virus documented for transmitting HPS to humans is the Sin Nombre virus. Its primary rodent host, the deer mouse, is the most abundant mouse in the United States.

The HPS causes a respiratory infection that initially causes flu-like symptoms. Following an incubation period of one to five weeks, the first signs include fever, chills, sweating, coughing, muscular and abdominal pains, nausea and vomiting. Without medical attention, fluid builds up in the lungs, adult respiratory distress syndrome occurs, and death can follow in an average of five days. Early treatment in an intensive care unit is important for surviving the infection. While the antiviral agent, ribavirin, has been effective in treating HFRS, treatment of HPS patients has not been shown to dramatically reduce mortality.¹

Hantaviruses produce a lifelong infection in rodents without any apparent disease to their hosts.² The viruses "emerge" when ecological disturbances bring hantavirus-infected rodents into closer contact with humans.³ In the Four Corners region in 1993, the local deer mouse population grew to 10 times that of the previous year, greatly increasing instances of infection.⁴ In the initial group of patients, approximately 80% died.⁵ Five months after the outbreak, the Sin Nombre virus strain had been identified and confirmed in 42 people in 12 states. Half of the 26 case patients that died had come from the Four Corners area.⁶

Although the highest caseloads of HPS still occurs in the Four Corners states, all states within range of the deer mouse are susceptible to the Sin Nombre Virus. As of August 3, 1998, the Centers for Disease Control and Prevention (CDC) Internet website notes that variations of the disease have been identified in 29 states, with 188 cases

reported. New treatments have been applied with some success, and the overall mortality rate has dropped to approximately 44%.

Viral transmission occurs in several ways: by inhalation of dried airborne particles of the rodents' saliva, urine, feces or carcasses; through broken skin or the eye; through rodent bites; or through ingestion of contaminated food or water. Virus exposure has been linked to such activities as heavy farm work, threshing, sleeping on the ground, and military exercises.⁷ The duration and period of maximum infectivity are unknown, nor is the virus' survival rate after being shed in the environment.⁸ Fleas, ticks, cats, and dogs are not known to transmit the disease to humans.⁹ At the time of this writing, the CDC maintains that humans have not transmitted the virus to each other in the U.S.

Preliminary NPS Mitigation Efforts

In response to the health and safety issues raised by this disease, the NPS initiated steps in the fall of 1993 to reduce the probability of contact and infection. Subsequent guidelines adapted from CDC recommendations emphasized control and prevention rather than eradication of the host species.¹⁰ This was to be achieved by eliminating rodents inside the home and work spaces, and preventing their re-entry. Rodent-proofing strategies included:

- Reducing the availability of food sources and nesting sites inside the buildings;
- Covering all openings greater than or equal to 1/4 inch, using steel wool, cement or screens; and
- Reducing rodent shelters and food sources within 100 feet of the occupied building.

The 1993 guidelines for rodent reduction and decontamination required initial ventilation of seasonal-use buildings and other structures that had remained closed for a period of time. A minimum 30-minute airing using an exhaust fan or cross ventilation was considered adequate time to remove any aerosolized virus. Following this provision, NPS interim measures recommended thoroughly cleaning areas displaying evidence of rodent activity, while avoiding raising dust or dirt into the air.

Destruction of the virus is dependant upon penetrating its protective shell. The virus' cell structure, the lipid envelope, is made of a fatty substance that is insoluble in water and serves to shield and protect the virus. It is susceptible to organic solvents such as diluted hypochlorite solutions or ethyl alcohol of 70%. These types of solvents can be found in most general-purpose household disinfectants.¹¹ The 1993 NPS guidelines specified saturation with a solution of detergent, water and a general-purpose household disinfectant

solution for cleaning floors and other durable surfaces. A second wiping down with a general-purpose disinfectant was optional. In lieu of a household disinfectant, the guidelines suggested a hypochlorite solution prepared by mixing three tablespoons of household bleach in one gallon of water.

All infected material, dead rodents, rodent nests and other tainted items were to be "double bagged" by placing them in polyethylene bags, sealed, and then placed in a second plastic bag and sealed. This bagged material was to be buried in a two to three foot hole, or disposed of according to local or state health department codes.

Special precautions for buildings with heavy rodent infestation, including vacant dwellings, required that workers wear plastic or rubber gloves, and protect their lungs with a half-face air-purifying respirator or Powered Air Purifying Respirator (PAPR) equipped with High Efficiency Particulate Air (HEPA) filters.¹²

A document in 1994, Technical Data Bulletin #110, January 1994 "Hantavirus Infection," goes beyond those recommendations given in the Park Service document to suggest even more extensive protective covering, including disposable coveralls, rubber boots or disposable shoe covers, rubber or plastic gloves, and protective goggles.¹³

Hantavirus Mitigation for Cultural Resources

In 1996, an interdisciplinary NPS team began restoration work on the Agate Fossil Beds' Bone Cabin. The decision was made early in the planning phase to proceed with the assumption that the Hantavirus could be in the area.

Preliminary decontamination, selective demolition and materials disposal were carried out by a team experienced in Hantavirus mitigation. Because formal mitigation training was not available, the team devised their protection procedures based on CDC and NPS guidelines. Some additional protective measures were taken by the team leader and approved by the Occupation Safety & Health Administration (OSHA). The mitigation team's protective clothing included full Tyvek suits, half mask air purified respirators with HEPA filter protection, splash goggles, booties and rubber gloves. For additional protection, the team wore heavy latex gloves under the rubber gloves. Organic/acid paper cartridges with HEPA pre-filters were used to protect against chlorine fumes. Ankle and wrist openings were sealed with duct tape.¹⁴

The Bone Cabin mitigation procedures followed much of the earlier CDC and National Park Service recommendations, with modifications to incorporate historic preservation principles and conservation measures. Because the focus of previous recommendations was health and safety, minimal written guidance was available involving alter-

Bone Cabin c. 1912-1914. Bedroom addition is on the left, main cabin at the center, and summer kitchen with attached wood shed on the right. Photo courtesy Agate Fossil Beds National Monument Collection.

native and less alkaline disinfectants for fragile historic materials. The NPS hantavirus health and safety standards for disinfectant solution require (by volume) a minimum of 10% household bleach. To date this formula has proven to be an effective approach when dealing with materials which are not intended for long term curation. However, the disinfectant mixture can be imprecise depending on product performance, the size of the application canister, and the type of measuring device used.

A 10% bleach to water solution was used on the wood members for the bulk of the mitigative efforts. The use of diluted bleach on wood members was considered a minimal concern due to the comparatively low pH variation between wood and bleach that would minimally effect the structural or cellular stability of the wood framing, siding, or finishes. The bleach solution contacted primarily surface areas and only a small percentage penetrated the wood substrate.

Shifting somewhat from a traditional curatorial approach for museum collections, the NPS staff customized procedures in order to disinfect the historic fabric samples and artifacts; to prevent their loss or destruction and rapid deterioration; and to minimize acidic contamination.

Lysol spray was used to penetrate the virus' lipid envelope. Its active ingredient, O-phenyl phenol, reduced the biological threat, and was a more neutral compound that would not bleach or cause fading. The pre-mixed spray offered better cover control of the aerosolized disinfectant to a precise targeted area, and limited damage to the surface and substrate of the recovered materials. Isopropyl alcohol in a distilled water solution could also have been used as an alternative disinfectant.¹⁵ This aspect of the project was speculative because it was not known whether the objects might suffer permanent damage.

Prior to any action on the building, a written and photographic documentation methodology systematically recorded historic materials before, during and after their removal. This approach maintained research integrity and provenance by linking the recovered architectural materials and other objects to their original physical locations.

Also prior to decontamination and demolition, representative materials samples of the wall, ceiling and floor finishes and trim details were removed by the properly-equipped mitigation



team, and treated outside of the building. As an added precaution, the outdoor treatment procedure was undertaken with face masks and latex gloves.

Many of these salvaged materials were water soluble or at least had the potential for water solubility. For this reason, spray application was superior to a brush or cloth application method to ensure control. Working in the field, questions of the stability or fugitive nature of ink, dye, or paint designs were unknown, nor whether the upper layers of the wallpaper samples might delaminate from the substrate. To avoid jeopardizing the integrity of the material and risk losing the pattern or the entire surface of the paper through short and long term storage, small areas were first tested with the Lysol spray. Neither bleeding nor migration of fugitive dyes occurred.

Following selective material sample removals, the team sprayed down all wall, ceiling and floor surfaces, sprayed in the crawl space, and washed out wall cavities of the west room. A mixing container with a control dial was filled with liquid Clorox bleach and attached to the end of a garden hose equipped with an adjustable nozzle. The nesting material and debris were washed out of the building, collected with shovels, and placed in trash bags. The bags were sealed with duct tape and disposed of in a local and state approved refuse landfill. The team disinfected themselves after each phase of selective demolition work by spraying themselves down with the bleach-to-water solution prior to removing their protective suits and masks.

As the clean out progressed more unexpected objects were found and treated with Lysol spray in the same manner as the representative finish samples. The salvaged items were diverse and included 20th century wood by-products and paper-base materials, linoleum, wood, leather, and flat glass. Differences in chemical composition characterize these objects: the wood and linoleum samples are

considered organic materials, while glass is inorganic. Again, a bleach solution was simply not a preferred option because the goal was to preserve the analytical potential of these objects. All samples were air dried, tagged with an identification code, and double bagged, and placed in temporary storage. The treatment application was intended to mitigate the biological threat and protect the cultural resources against further loss, material weakening, and other forms of deterioration.

Cooperation with the mitigation team allowed recordation of unforeseen findings to proceed in a safe manner. Discoveries including cardboard box wall covering from the 1930s or 1940s, the Harold Cook-era tongue and groove wallboard, and an encased door answered some important questions about how the cabin had been used by its consecutive inhabitants.

The wallboards created an interesting dilemma: because the tongue and groove boards were installed by Harold Cook as a finish material, the decision was made to retain the material while disinfecting the wall cavities, and discourage future nesting. The solution was to wash out the cavities from the exterior. The condition of the original exterior shiplap siding was too poor to salvage, so select boards were removed in order to access the stud wall cavities. The same garden hose with a bleach-to-water filled container was used to flush out the cavities.

To discourage future nesting, fine steel wool was inserted into any accessible cavities, while the stud walls of the kitchen and main cabin remained exposed. All openings 1/4 inch or larger were covered with sections of sheet metal, in a manner similar to the method used by the original occupants. A rodent trapping program will be implemented by the park unit to assist in the rodent population reduction program.

Restoration and stabilization then commenced, with some precautions still in place. The protective mitigation clothing was not worn during this phase, due to the extensive disinfection with

bleach solution, and the fact that the remaining construction work was primarily on the exterior.

Nearly one year after their removal, a Level II assessment of the sample materials and artifacts was performed to review and evaluate their intrinsic value. The cardboard samples contained documentary printed information useful in the interpretation of the period and the structure. However, because cardboard contains a large percentage of lignin and is highly acidic, it presented tremendous preservation problems.

The objects were unbagged and surface cleaned. Surface cleaning was accomplished using a vacuum and crevice tool attachment or a soft bristle brush. Proper equipment included a hand-held HEPA filter vacuum, a dust/mist respirator

and latex gloves. All of this work was conducted in a well ventilated work staging area. Photo-documentation of all the inherently acidic objects captured their intellectual content; the images would become part of the object catalog file. With their useful information documented, the actual cardboard was discarded.

After cleaning and documentation, the samples were then considered treated, and boxed for storage. The samples had been stored previously in an unmonitored building, and some wood or paper-base materials may have accumulated additional moisture.

Such samples have

been returned to the same location, and will be tested for moisture content in the near future. A selection of fabric, paper and composite samples have been sent to a conservation laboratory to begin the process of conservation.

The success of this project is largely due to a shared preservation philosophy and an integrated, holistic planning process that addressed many long term preservation issues in the context of an immediate biological threat to human health and safety. The structure and historic fabric will continue to serve as primary sources of cultural and scientific information and further support the

Spraying down the exterior wall in the mitigation effort.



park's resource management and interpretive programs.

Long term storage and preservation issues at the Bone Cabin make this case study valuable for future projects. Similar mitigation procedures have since been undertaken at other parks in the Midwest Region, but it is worth noting that in any hantavirus mitigation project, some improvisation and compromises will be necessary. For these and all future Hantavirus mitigation work, proper safety clothing and protection equipment is essential. Each team member who is expected to work in an area believed to harbor pests must receive a medical examination to determine the individual's fitness to wear a full face respirator. In addition, thorough recordation procedures and well-conceived storage recommendations or plans should be in place prior to initiation of the work.

Notes

- ¹ Ali S. Kahn, et al., "Hantavirus Pulmonary Syndrome: The first 100 Cases," *The Journal of Infectious Diseases*, 173 (1996), 1300; and The Centers for Disease Control and Prevention, "Hantavirus," subtitle Treatment, <<http://www.cdc.gov/ncidod/diseases/hanta/hps/physician/treatment.htm>>, July 1997. Comparatively, the mortality rate for HFRS in Eurasia is 2% to 10%. See The Centers for Disease Control and Prevention, "Hantavirus" subtitle Other Hantaviruses.
- ² Brian Hjelle, M.D., "Hantaviruses, with Emphasis on Four Corners Hantavirus," Department of Pathology, University School of Medicine, 14 March 1995, <<http://www.bocklabs.wisc.edu/ed/hanta.html>> May 1997.
- ³ Kahn, note 1 at 1301.
- ⁴ The Centers for Disease Control and Prevention, "Tracking a Mystery Disease: the Detailed Story of Hantavirus Pulmonary Syndrome," <<http://www.cdc.gov/ncidod/diseases/hanta/hps/outbreak.htm#OUTBREAK>>, July 1997.
- ⁵ Hjelle, note 2. Dr. Ali S. Kahn of the CDC notes that the retrospective diagnosis of case-patients from as early as 1959 previously occurred and resulted in HPS, but went unrecognized. See Kahn note 1 at 1301.
- ⁶ "Technical Data Bulletin #110 January 1994, Hantavirus Infection," (3M company?, photocopy), 1.
- ⁷ Connie Schmaljohn and Brian Hjelle, "Hantaviruses: A Global Disease Problem," *Emerging Infectious Diseases*, 3:2 (April-June 1997), 95; Charles R. Vitek, et al., "Evidence Against Infection with Hantaviruses Among Forest and Park Workers in

the Southwestern United States," *Clinical Infectious Diseases* 23 (August 1996): 283-285; and The Centers for Disease Control and Prevention, "The Rodent Connection," <<http://www.cdc.gov/ncidod/diseases/hanta/hps/transmit.htm>>, July 1997.

- ⁸ "Hantavirus Infection Interim Recommendations for Risk Reduction," Public Health Service, National Park Service (November 1993), 2.
- ⁹ National Park Service, "Hantavirus Disease Health and Safety Update," *Conserve O Gram* 2 no. 8 (July 1995), 1.
- ¹⁰ The guidelines produced by the NPS were established in the November issue of the "National Park Service Hantavirus Infection Interim Recommendations for Risk Reduction." See also "Centers for Disease Control and Prevention: Hantavirus Infection-Southwestern United States. Interim Recommendations for Risk Reduction," *Morbidity and Mortality Weekly Report* 42 no. RR-11 (1993), 1-13.
- ¹¹ David L. Levy D.O., "Hantavirus Pulmonary Syndrome: Outbreak of a New Disease Caused by a New Virus," *Postgraduate Medicine* 97 no. 3 (March 1995), 127-139; Monona Rossol, Industrial Hygienist with Arts, Crafts & Theatre Safety, Inc., telephone conversation and electronic mail to Carolyn Wallingford, May 1996; Wendy Jessup, Jessup and Associates, Inc., telephone conversation to Carolyn Wallingford, April 1996.
- ¹² A cautionary note was made in the "Technical Data Bulletin #110 January 1994, Hantavirus Infection," (3M?), page 2, that there was no way to determine the efficacy of any respirator for use in protection against bioaerosols.
- ¹³ Ibid., 3.
- ¹⁴ Rossol. Rossol confirmed the protective measures recommended by the CDC.
- ¹⁵ Jessup and Rossol.

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